The One-Dimensional Superconducting Photonic Crystal

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Abstract**: By using **transfer matrix method, the transmittance of 1D-superconducting-dielectric photonic crystals (1D-SPCs) was calculated. The variance of the intensity and the bandwidth of the transmission are strongly dependent on the thicknesses, temperatures, and number of periods. We, also, obtained a new behavior at different critical temperatures of superconductor materials.

One-dimensional PCs of this kind are simply periodic multilayer structures that were intensively studied in the past [1], but still attract significant attention Moreover; study of electromagnetic response for 1D-SPCs is a useful and common means of understanding basic physics of the superconducting materials [2]. Theoretical calculation on the microwave transmission and reflection for a type-II superconducting film on a dielectric substrate was first reported by Coffey and Clem [3]. It belongs to a propagation-dominated problem because the structure of interest is generally a layered medium. A periodic layered structure also is called a superlattice that has been attracting much attention in condensed matter physics. Superconductor superlattice was reported earlier in Ref. 4. Later, calculations of surface impedance of a superconductor superlattice in the mixed state were made by Tagantsev and Traito [5]. Recently, superconduc interpretation tor/dielectric superlattice has been further regarded as a photonic crystal and the associated photonic band structure has been explored [6-8]. It is possible that the results have been used in the design of high reflection mirrors, beam splitters, and bandpass filters [9].

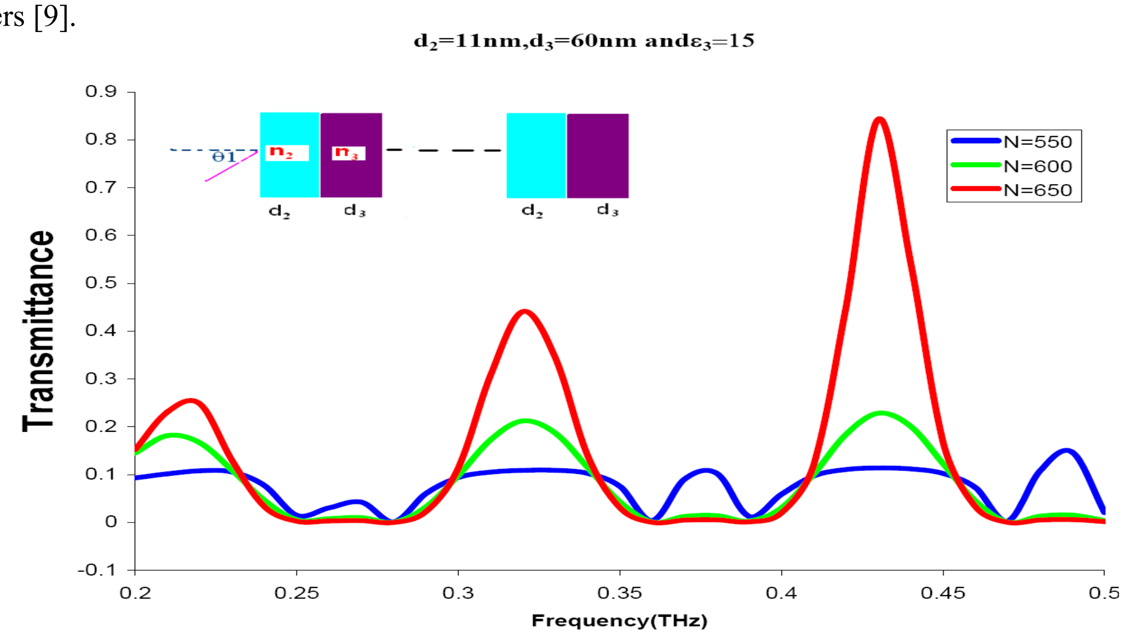

Fig.1. Transmittance spectra dependence on the periods. Inset, 1D-ScD multilayer.

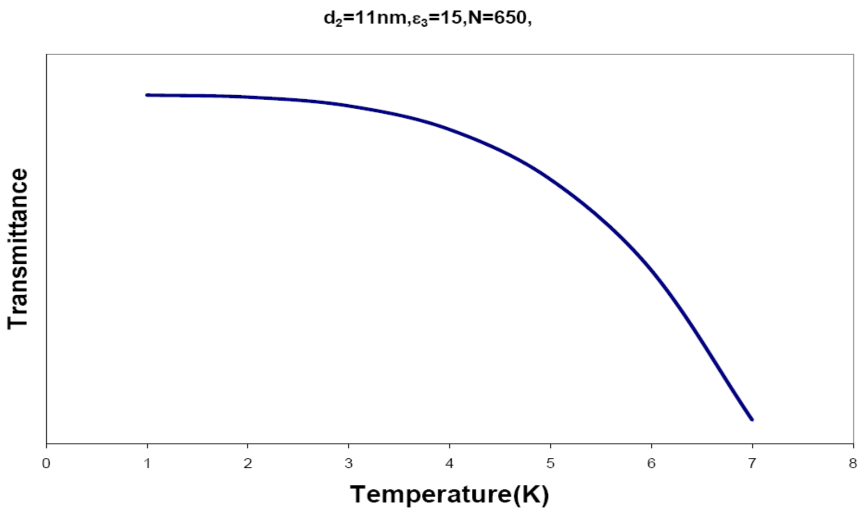

Fig.3 Transmittance dependence on the temperature

We use the two-fluid model to describe the electromagnetic response of a typical superconductor without an applied magnetic field. We consider that a TE wave (see the inset of fig.1) is incident at an angle θ_1 from the top medium which is taken to be free space with a refractive index, $n_1 = 1$. The index of refraction of the lossless dielectric is given by $n_3 = \sqrt{\varepsilon_{r3}}$, where ε_{r3} is its relative permittivity. For the superconductor, the index of refraction, n_2, can be described on the basis of the conventional two-fluid model .

Fig.1 showed the frequency-dependent transmittance for different periods. The transmittance spectra change a lot when we increase the periods from 550 to 650. The magnitude of transmittance is increased to 0.85 at 650 periods. It is good advantage to superconductor photonic crystal. The superconductor is strong sensitive to the temperature. When the temperature is above 5K in fig.2, the transmittance begins to decrease sharply such as in the transmittance of the Mach-Zehnder interferometer [10]. We can see that the transmittance can be tuned from about 90% to 1%, showing that the optical device we proposed here could serve as an on-off switch in the far-infrared region [10].

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